



# **Development of the Novel Evaluation Tool with an In-situ Ellipsometer for the Thickness Measurement of the Contamination Originated by the High Power EUV Irradiation on EUV Resist**

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# Outline

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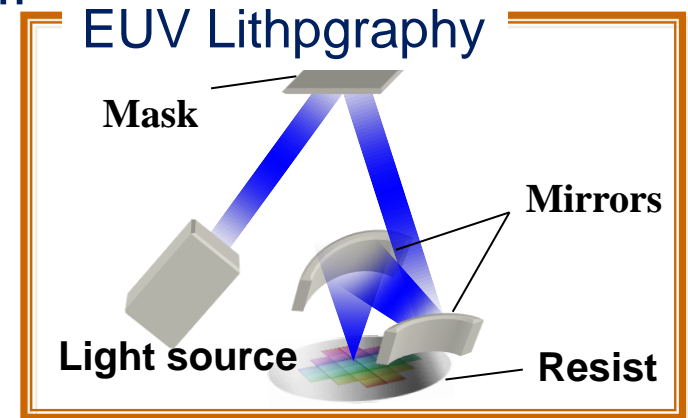
1. Introduction
2. Overview of the novel contamination evaluation tool
3. Outgassing characteristics of the vacuum stage with the motorized vacuum stage
4. Vacuum pressure of the main chamber
5. Carbon contamination thickness measurement using the in-situ visible light spectroscopic ellipsometer
6. Summary



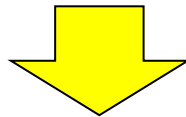
# Background

The third EUVL issue is to develop which has the high sensitivity, the low line edge roughness, and the high resolution simultaneously. In addition, low outgassing characteristics.

- **High sensitive**
- High resolution
- Low LWR
- **Low outgassing**

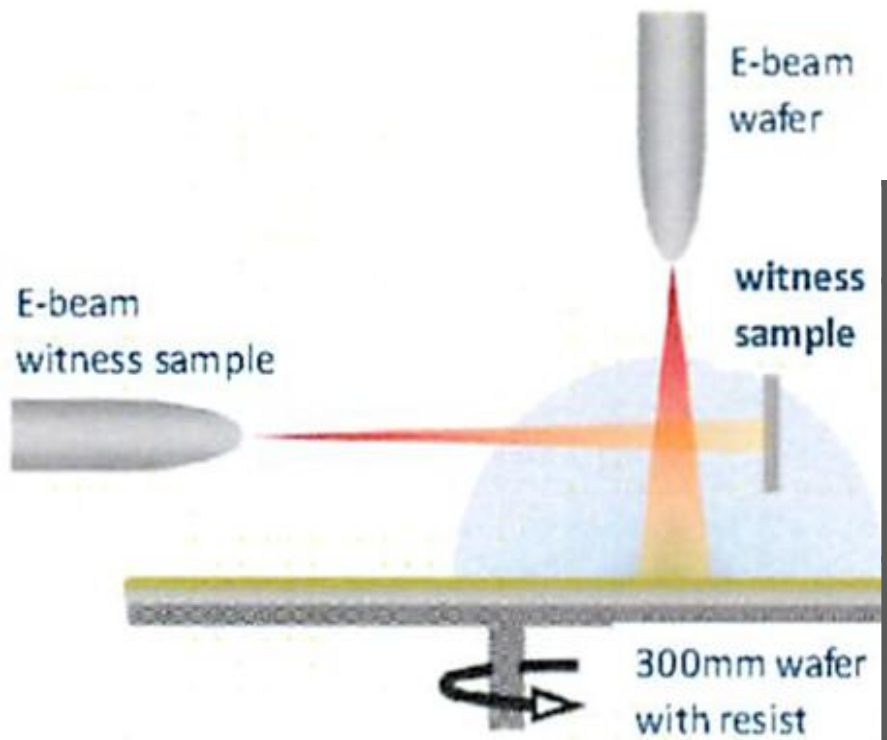


The hydrocarbon outgassing species from the resist introduces the carbon contamination adhesion on mirrors and mask in EUV irradiation. As a result, it affects the lithographic throughput and the resolution. The outgassing study has been studied, however the relationship between the outgassing species and the contamination thickness has not been clarified yet.



ASML suggested to use EB for the contamination adhesion evaluation.

# The contamination evaluation by ASML



## The difference in EUV and EB.

	By EUV exposure	By EB exposure
Re-action	Acid yield ↑ • Ionization • Photoexcitation • Inner shell excitation	Acid yield ↓ • Ionization
Sensitivity	Not completely same, some PAG has higher sensitivity in EUV.	

ASML set-up (using electron beam)

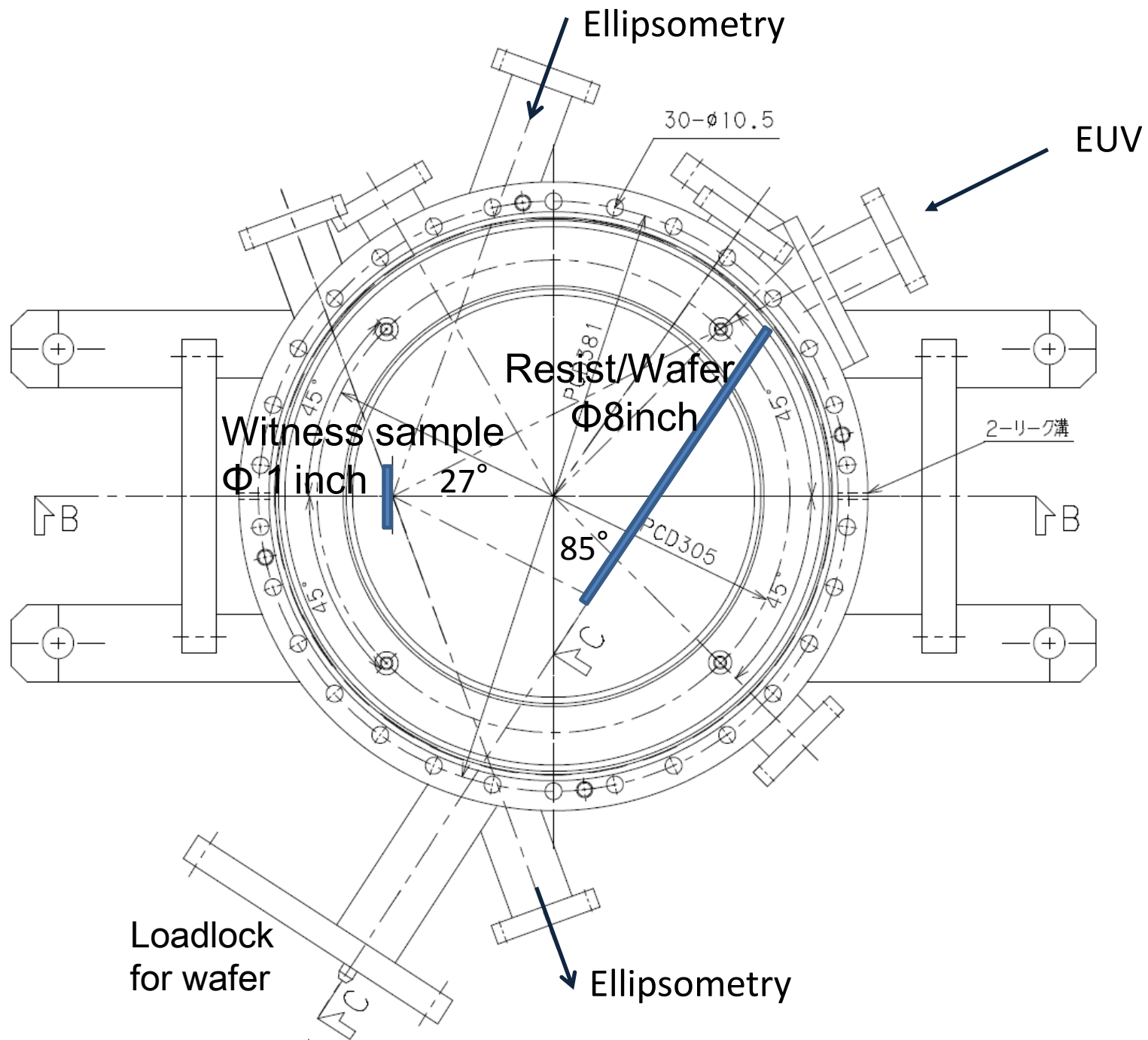
SPIE Feb.16, 2010, 7636-69\_Poster

I. Pollentier, A-M. Goethals, R. Gronheid, J. Steinhoff\*, and J. Van Dijk\*, IMEC, ASML

# Objective

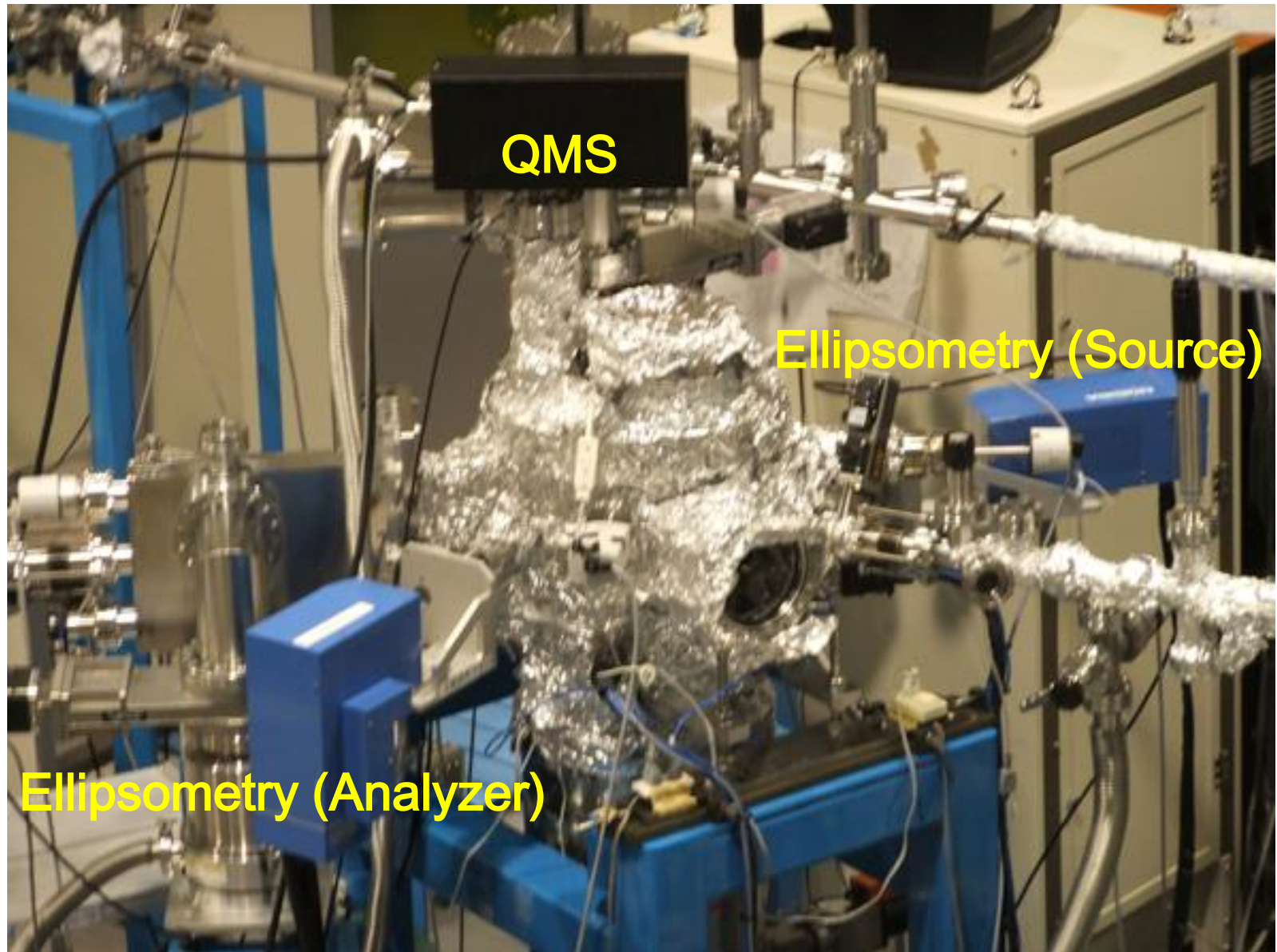
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- 1) The relationship between the outgassing species and the contamination adhesion would be clarified in EUV irradiation. And the contamination adhesion difference between in EUV and EB irradiations could be clarified.
- 2) The thickness of the carbon contamination would be measured by the in-situ ellipsometry in EUV irradiation.
- 3) The database construction of the contamination in EUV and EB irradiations would be performed. And the database is used for the design and developing the low outgassing resists.

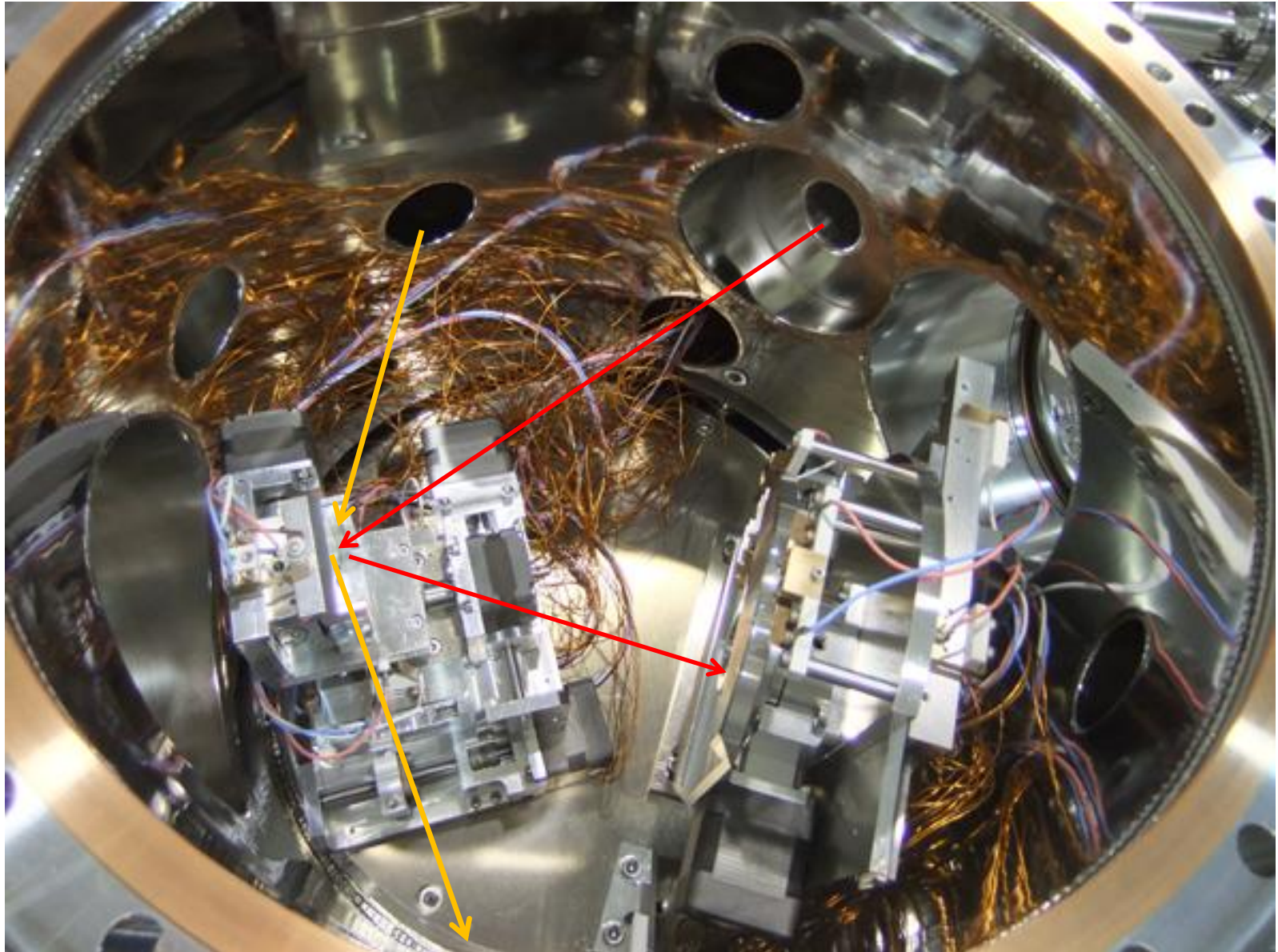




# Novel contamination evaluation tool



# Witness and resist sample vacuum stages



**Witness stage**

**Resist stage**

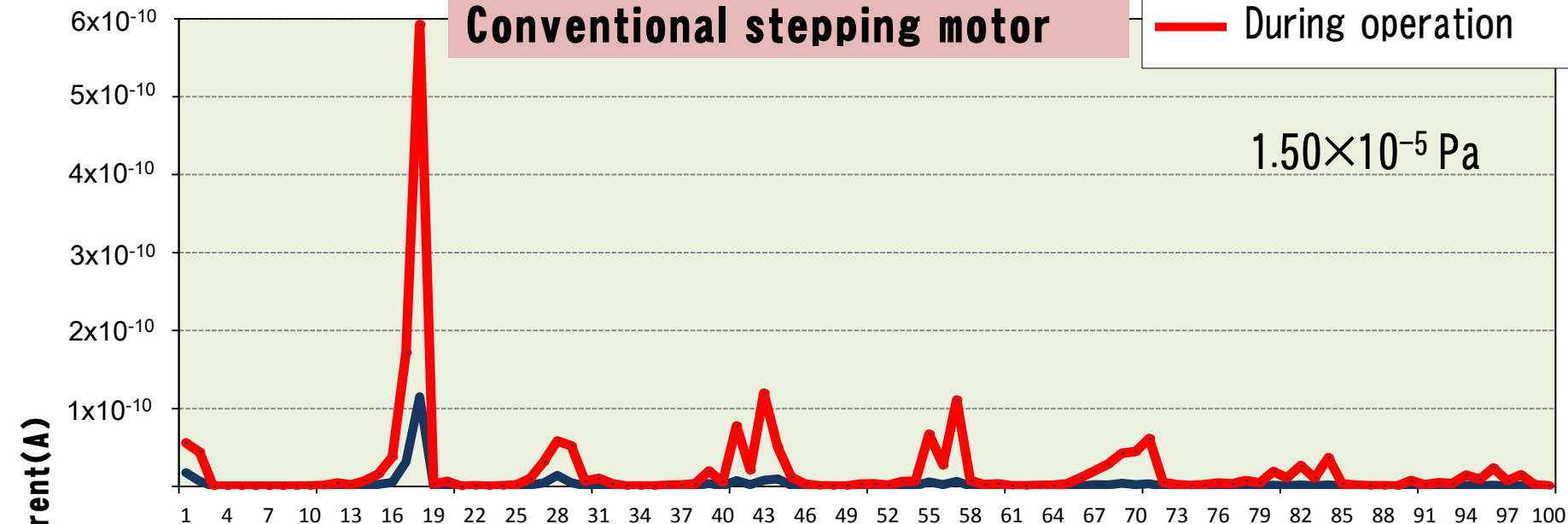


# Outgassing characteristics using QMS

— Before operation  
— During operation

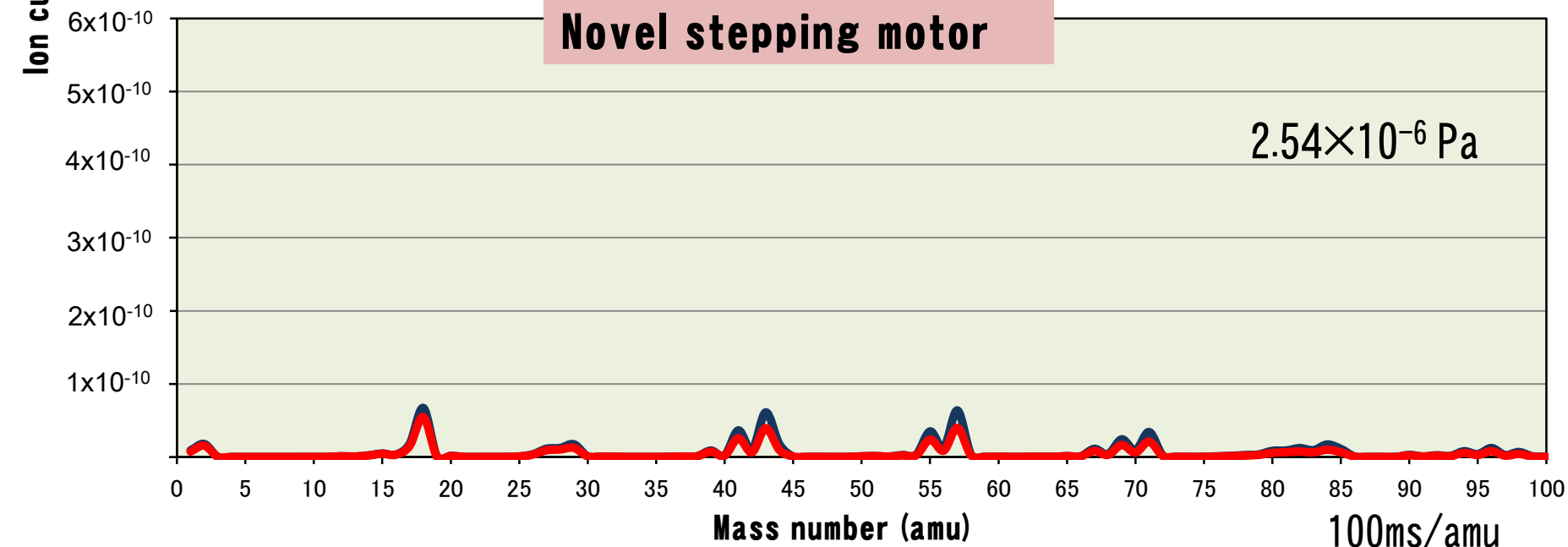
## Conventional stepping motor

$1.50 \times 10^{-5}$  Pa

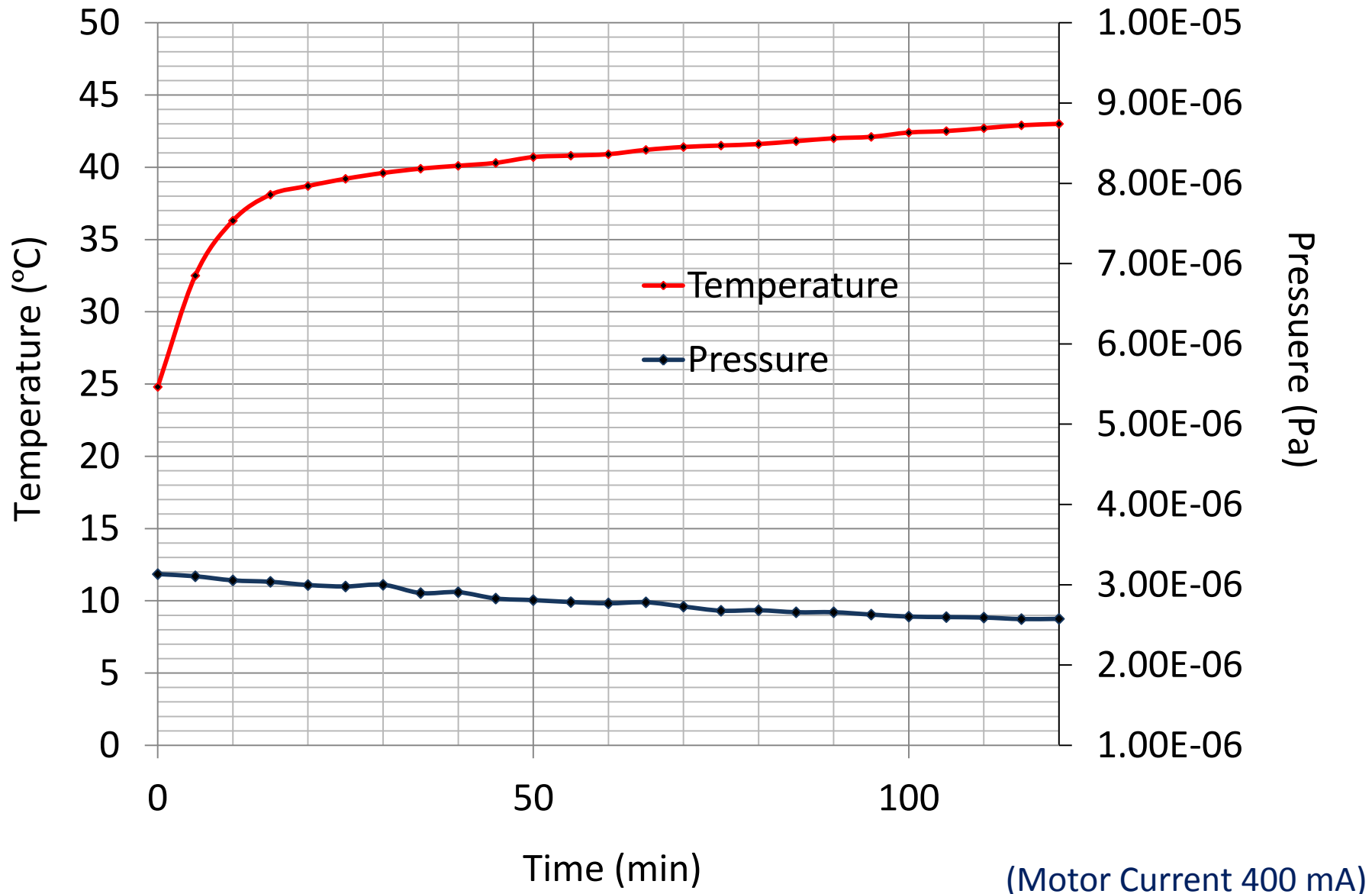


## Novel stepping motor

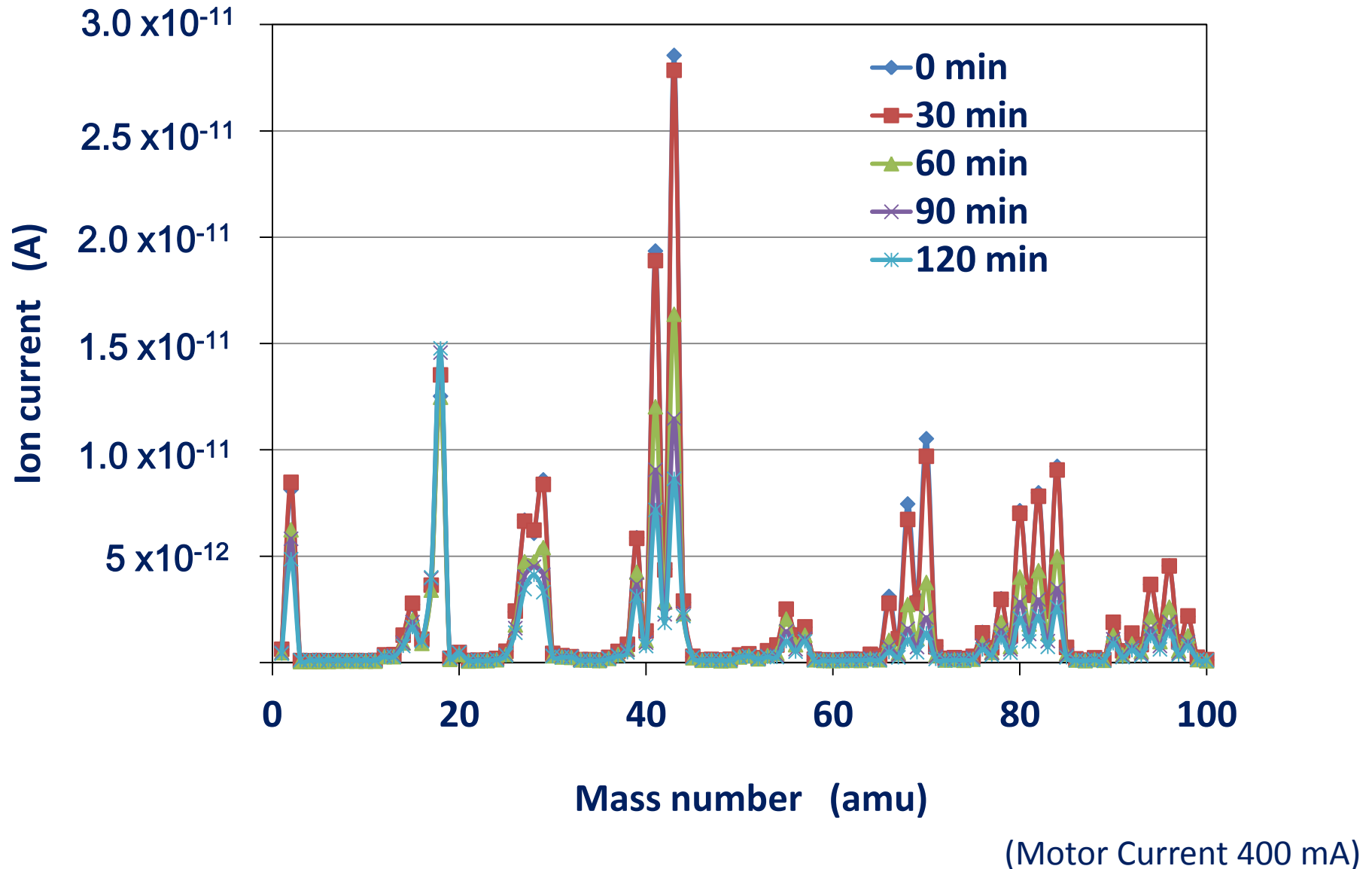
$2.54 \times 10^{-6}$  Pa



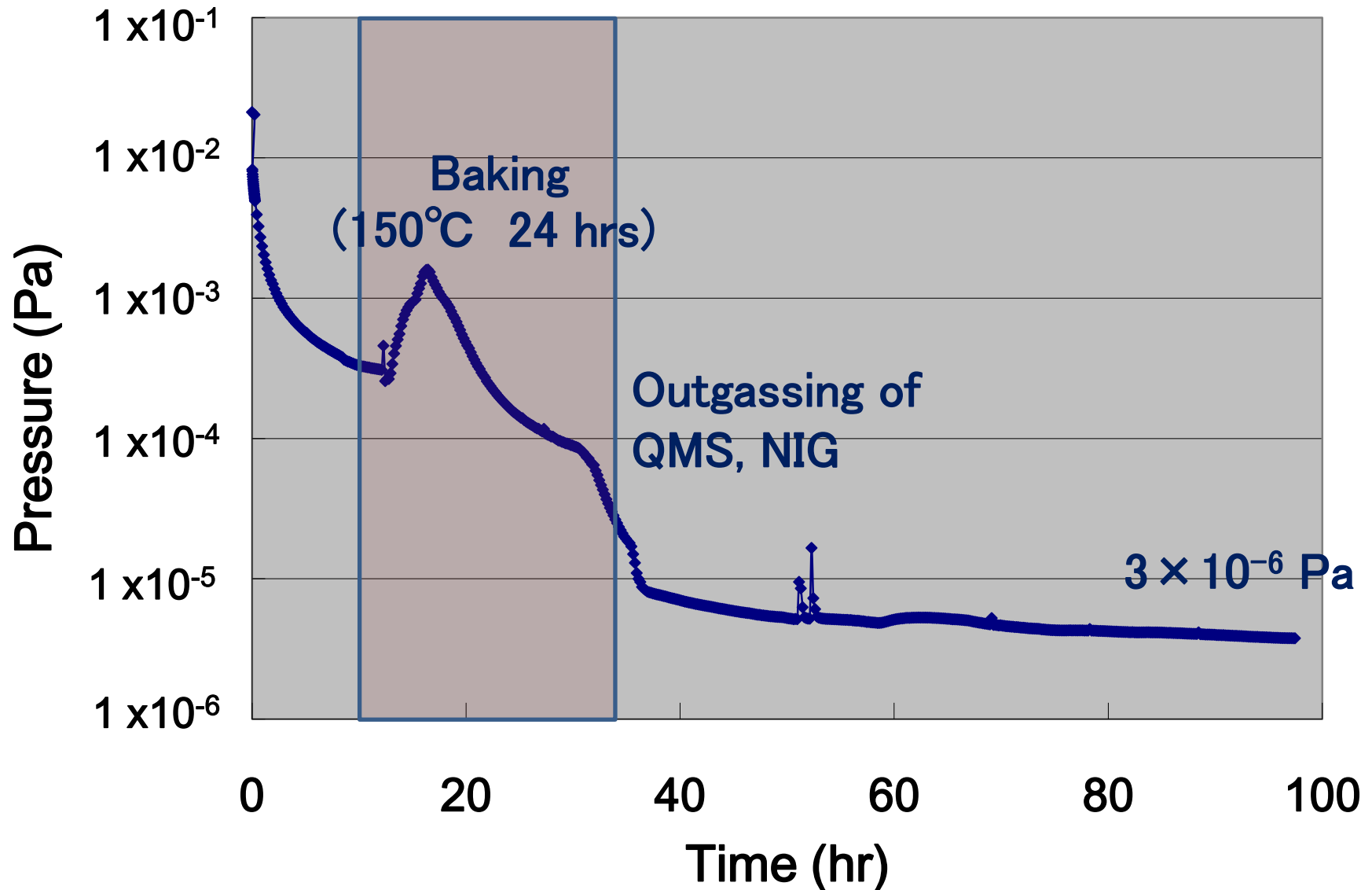
# Vacuum Pressure and the Temperature of the Resist Rotation-Stage during the Operation



# The Mass Spectra of the Resist Rotation-Stage during the Operation



# The First Step to Achieve High Vacuum Pressure of the Main Chamber



# EUV Exposure Intensity

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On a witness sample     267 mW/cm<sup>2</sup>

On a resist sample     124 mW/cm<sup>2</sup>

(Depends on the reflectivity of Mo/Si MLs)

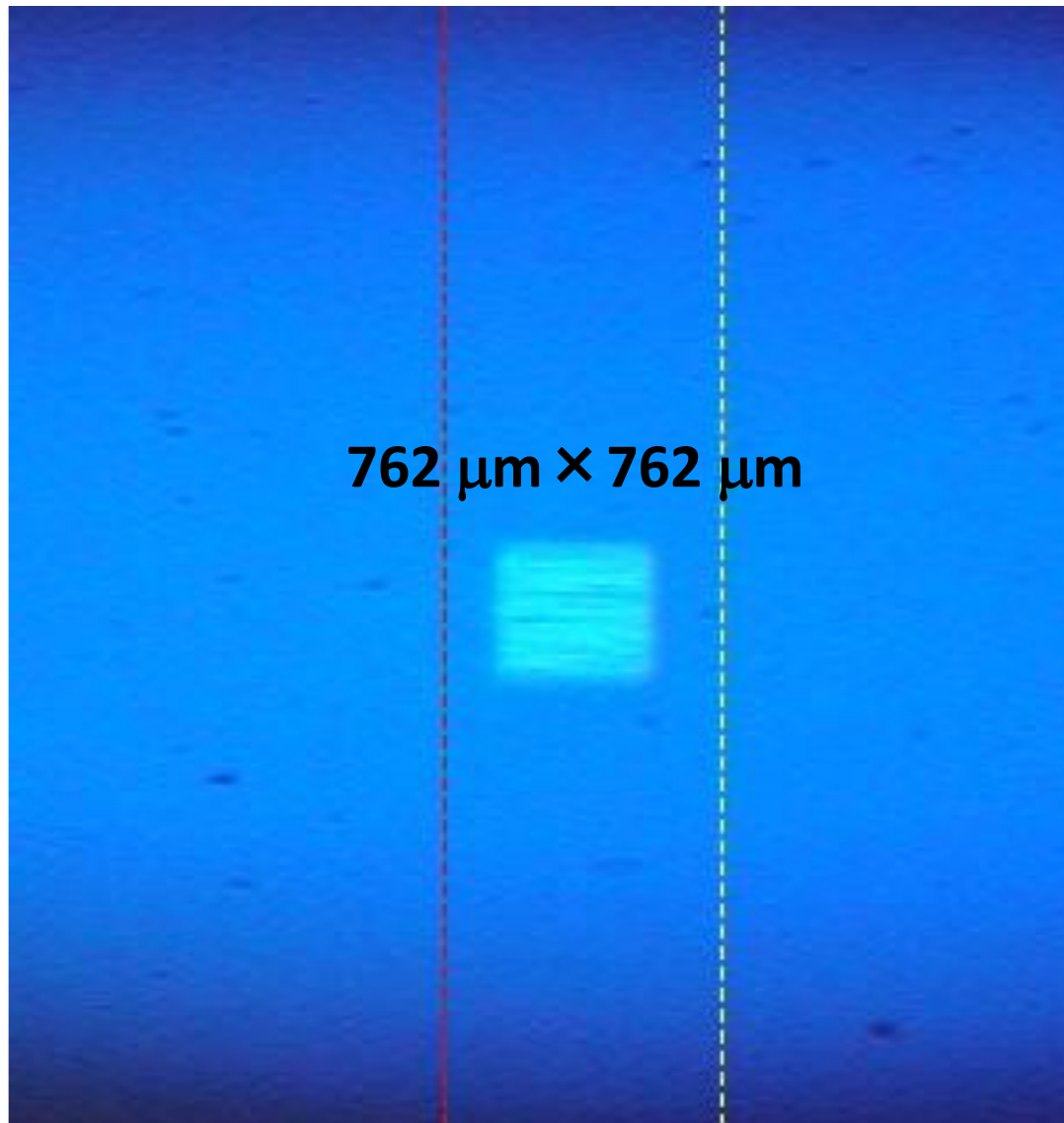
**NewSUBARU storage ring operation conditions**

- 1.0 GeV TopUp mode operation
- Storage ring electron beam current   250 mA



# The ellipsometer CCD image on a witness sample

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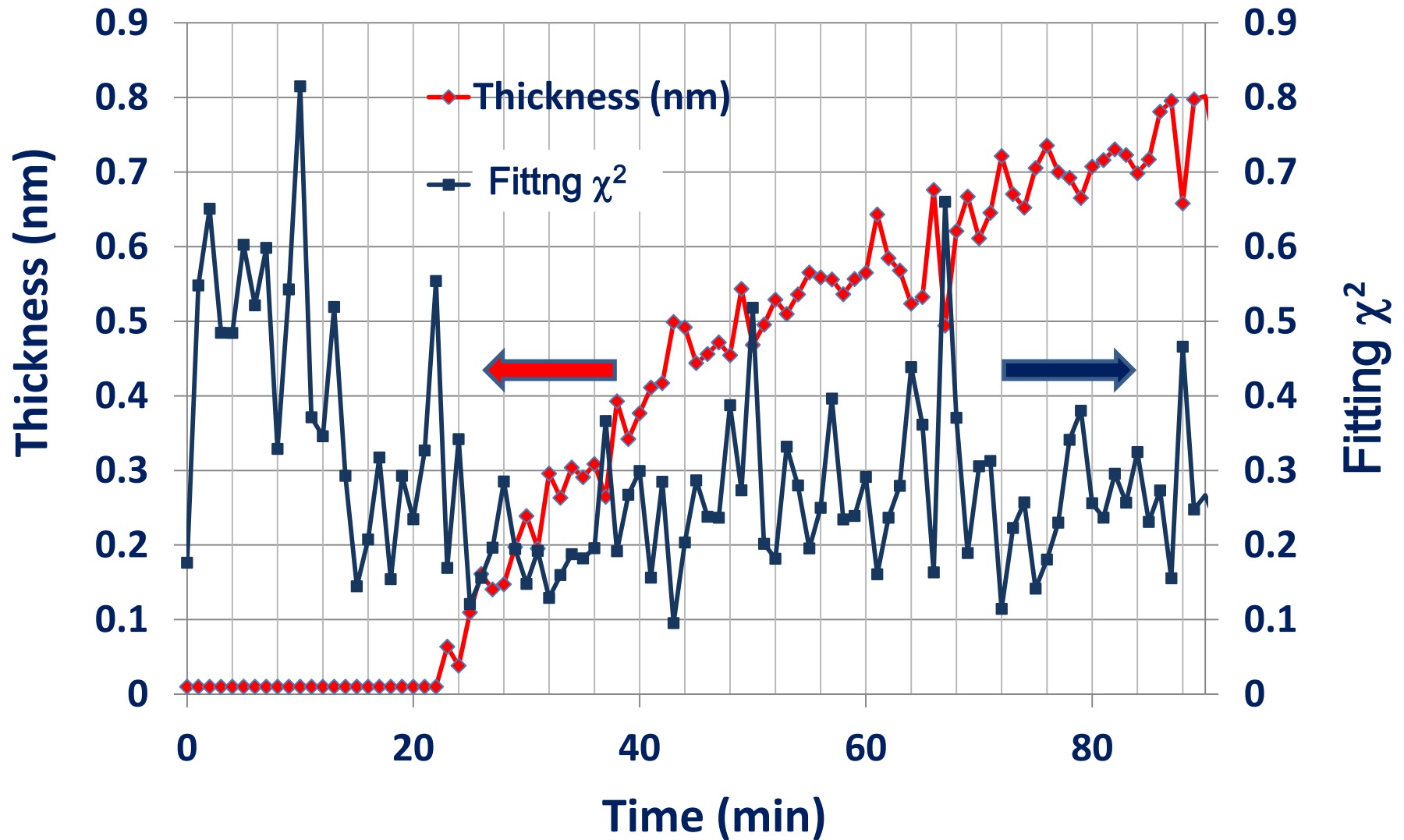


Phase-modulation-type  
spectroscopic  
ellipsometer

Wavelegth region  
450 nm ~ 1000 nm

Optical axis alignment  
of the ellipsometer:  
Witness sample stages  
Z,  $\alpha$ ,  $\beta$ -axes

# The in-situ carbon contamination thickness measurement



# Summary

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- 1) The first achievement of the vacuum pressure of the main chamber was  $3 \times 10^{-6}$  Pa. The current base pressure is  $8 \times 10^{-7}$  Pa.
- 2) The specification of the in-situ visible spectroscopic ellipsometer satisfies the carbon contamination thickness measurement.
- 3) It was confirmed that using this system, the carbon contamination thickness measurement in high power EUV irradiation was achieved.



## Future plan

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**With the same EUV power level in HVM, using the ion-counting-type QMS and the in-situ visible spectroscopic ellipsometer, the relationship between the resist outgassing species and the contamination adhesion could be clarified. And then the results might be feedback to the EUV resist design and development.**



# Acknowledgement

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These results were obtained under the collaboration supports of NEDO and EIDEC, and the recomissioning by EIDEC.

